FINAL PROJECT

DESIGNING A CHLOROFORM PLANT USING ACETONE AND CHLORINE WITH CAPACITY 19,000 TONNES PER ANNUM

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ABSTRACT

Development in construction which keeps on increasing each year is also followed by increases in the need of society. Indonesia still has not built any chloroform manufacturers. This makes development of chloroform manufacturers in Indonesia will have a good prospect as it is very profitable and able to reduce dependence on imports of chloroform as well as to diversify products with high economic values which in turn add to state revenues and provide employment. Chloroform is popular for its use as an anesthetic, despite its wider use as a nonpolar solvent in laboratories or by industries.

To meet the need of society for chloroform, Indonesia is still importing from other countries. the manufacturer capacity is then determined to reach 19,000 in the Cilegon,Banten. Chloroform produce by aceton and chlorine. Reaction between acetone 1294.227 kg/annum and chlorine 12942.272 kg/annum using reactor that have agitator and there is a heating coil at temperature $50^{o}C$ and pressure 1 atm also 2 hours for reaction. Besides being the main product, chloroform within reactor also produces calcium acetate $Ca(CH_3COO)_2$, calcium hydroxide ($Ca(OH)_2$), calcium chloride ($CaCl_2$).with area of plant is 48.732 m^2 , this plant will be manufacture at 2015.

From economic analysis can get the ROI (Return on Investment) before and after tax are 136.429% and 95.374%, POT (Pay OutTime) before and after tax are 0.68 years and 0.95 years, BEP (Break-evenPoint) 41.31%, and SDP (Shutdown Point) 35.72%.While DCF (Discounted Cash Flow) as 45.36%. From the economic analysis, this plant recomended for manufacture.

Keywords : Chloroform, Acetone, Chlorine.

CHAPTER I.
OVERVIEW

1.1 Background

Development in construction which keeps on increasing each year is also followed by increases in the need of society. One of the promising industries in the field of chemical engineering is chloroform. So far, Indonesia still has not built any chloroform plants. This makes development of chloroform manufacturers in Indonesia will have a good prospect.

Molecular formula of chloroform is $CHCl_3$. At normal pressure and temperature, it is a clear liquid with a typical smell. Even though the need for chloroform in Indonesia continues to increase over time, Indonesia remains highly relying on imports from abroad to satisfy the need.

Chloroform is popular for its use as an anesthetic, despite its wider use as a nonpolar solvent in laboratories or by industries.

1.2 Purpose

Manufacturing of chloroform plant, have a purpose :

1. reduce dependence on imports of chloroform
2. diversify products with high economic values which in turn add to state revenues and provide employment
3. Price of chloroform more chips caused product from owner country.

CHAPTER II
LITERATURE REVIEW

2.1 The Designed Production Capacity

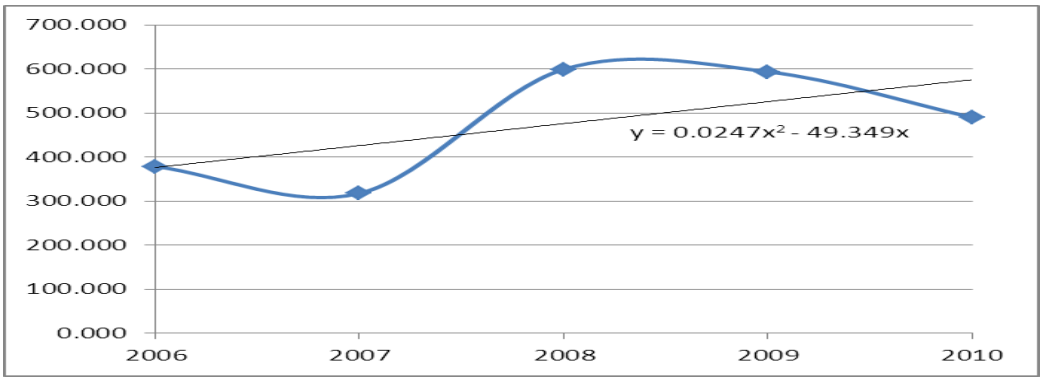
Some factors taken into account to determine the designed capacity of a chloroform manufacturer are :

a. The Need for Chloroform in Indonesia, can shown from this table 2.1 and figure 2.1 :

Tabel 1.1 Data Imports chloroform in Indonesia from 2006 to 2010.

Years	Chloroform imports (ton)
2006	378,733
2007	317,820
2008	599,266
2009	593,659
2010	490,019

Figure 1.1 Graph need of chloroform in Indonesia



And get the equation is :

$$y = 0{,}0247x^2 - 49{,}349\ x$$

b.The Need for Chloroform Overseas

Need of chloroform in overseas can shown in table 2.2.

Tabel 1.2 The Need for Chloroform Overseas at 2006 – 2010.

Years	Ton
2006	331.791
2007	338.847
2008	345.909
2009	352.979
2010	360.055

Using the factors above and the projection based on the calculation of the of The Processincrease in chloroform imports per annum, the designed production capacity in 2017 which amounts to 19,000.

2.2 Types of the Processes

Types of process to produce chloroform, dived by :

1 Photochemical Chlorination

2 Reduction of Carbon Tetrachloride

3 Reaction between acetone and chlorine.

From types of produce chloroform, with any advantages and disadvantages, so plant design of chloroform choose fourth process, reaction between acetone and chlorine with ratio 0.045 of acetone : 0.453 of chlorine. Ranges of yield that produce is 86 to 91%.

The reaction took place at a temperature of 50º C and 1 atm pressure in an exothermic reaction in the reactor batch.

CHAPTER III
RESEARCH METHODOLOGY

3.1 Thermodynamics Review

The determination of exothermic or endothermic reaction is considered from the calculation of standard reaction heat (ΔH_r). For calculation ΔH_r can be calculated based from ΔH_f^o data each component and using this formula :

$$\Delta H_r = \Delta H_{f\ produk}^{o} - \Delta H_{f\ reaktan}^{o}$$

So, we can get the value of ΔH_r is -305,634 kJ/mol. Because the value of ΔH_r is negative, the reaction of chloroform production is exothermic. To find out the direction of a reaction in thermodynamics aspect,we must calcultate value of reaction equilibrium (K), using :

$\Delta G^o = - R.T.\ln K$

$$\frac{d \ln K}{dT} = \frac{\Delta H_r}{R\,T^2}$$

Tabel 2.2 Data of Gibb's free energy every component at 298K

No.	Component	ΔG^o_{298} (kJ/mol)
1	CH_3COCH_3	- 153,304
2	$CaOCl_2.H_2O$	0
3	$CHCl_3$	70,405
4	$Ca(CH_3COO)_2$	0
5	$Ca(OH)_2$	- 899,040
6	$CaCl_2$	- 748,608
7	H_2O	- 237,304

and get the value of ΔG^o is - 5.020,31 kJ/mol. From this result, we can continue to calculate equilibrium constant of the reaction as :

$\Delta G^o = - R.T.\ln K_o$

$$\ln K_o = - \frac{\Delta G^o}{R\,T}$$

$$\ln K_o = \frac{5.020.310}{8{,}314\,.\,298}$$

$$\ln K_o = 2{,}026.302$$

Caused reaction equilibrium (K_1) is very large so it can be concluded that the reaction occurs in the process of chloroform forming is running irreversible.

3.2 Review Kinetics

Reaction to form of chloroform is :

$CH_3COCH_{3(l)} + 6\ CaOCl_2.H_2O_{(s)} \longrightarrow$

$2\ CHCl_{3(l)} + Ca(CH_3COO)_{2(s)} + 2\ Ca(OH)_{2\,(s)} + 3\ CaCl_{2(s)} + 6\ H_2O_{(l).}$

$$-r_A = -\frac{dC_A}{d_t} = -\frac{dC_B}{d_t} = k.C_A.C_B$$

With :

$C_A = C_{A0}\,(1-X_A)$

$C_B = C_{A0}(M - \frac{b}{a}\,.X_A)$

$$t = \frac{1}{k.C_{A0}.(M - \frac{b}{a})} \ln\left[\frac{M - \frac{b}{a}X_A}{M(1-X_A)}\right]$$

$$t = \frac{1}{1{,}81.10^{-8}\ x0{,}013x(0{,}561 - \frac{6}{2})} \ln\left[\frac{0{,}561 - \frac{6}{2}x0{,}91}{0{,}561x(1-0{,}91)}\right]$$

$t = 1.831$ hours ≈ 2 hours

3.3 Main Equipment Spesification

1 **Reactor Batch**

- Code: R-110
- Function: Reaction between chlorine and acetone,will produce chloroform for 2 hours.
- Volume : 70.979 m^3
- Amount : 4 buah (parallel)
- Dimension:

  Height = 6.30 m

  Diameter = 4.572 m
- Agitator : Turbin

  Diameter = 1.524 m

  Height = 0.305 m

  Width agitator= 0.381 m

  Width baffle = 0.457 m
- Material : *Stainless stell SA 167 type 304*

2 Mixer 01

- Code : M-110
- Function : Dissolving chlorine with water
- Type : Vertical cylinder with head and bottom shaped torispherical
- Amount : one
- Agitator :

  Type : marine propeller with 3 blades and 4 baffle

  Diameter : 1.560 m

  Rpm : 47.316 rpm

  Tenaga motor : 2 HP
- Material : Carbon steel grade CSA-285

3 Coloumn Destillation

Code :D-110

Function :Make a pure chloroform.

Type : plate coloumn with sieve tray

Condition operation

Pressure : Feed = 1 atm

Top = 1 atm

Bottom = 1 atm

Temperature : Feed = 73^{o}C

Top = 60,5^{o}C

Bottom = 99,2^{o}C

Shell :

Diameter : Top = 0.928 m

Bottom = 0.928 m

Thick : Top = 0,0048 m

Bottom = 0,0048 m

Material :Stainless stell SA 167 type 304

Height Shell : 20.05 m

Column Height:16.957 m

Thick head : Top = 0,0048 m

Bottom= 0,0048 m

Height head : Top = 0,2068 m

Bottom = 0,8683 m

Material :Stainless stell SA 167 type 304

Plate : Type : Sieve tray

Amount plate : 25

Feed plate : 11

Material : Stainless stell SA 167 type 304

4 Decanter

Code : H-110

Function :Separating the main product of byproducts use density.

Amount : 12

Diameter : 3.727 m

Length : 11.180 m

Material : Stainless stell SA 167 type 30

3.4 Operational value

There is fourth process to produce chloroform, as :

1. raw materials preparation stage

- Mixing chlorine and water with the ratio 1.36 kg : 3.785 liter water to makes liquid chlorine.
- organize the ratio of acetone and chlorine by 0.045 : 0.453 (kg)

2 Reaction Stage

The liquid from the stage of raw material preparation with the ratio 0.045 kg : 0.453 kg (acetone: chlorine) flown to batch reactor.

3 Product Purification Stage

- Product from batch reactor is chloroform and side products as calcium acetate, calcium hydroxide, calcium chloride, in decanter (H-110) will be separated by size particle and density.
- The result of decanter in the form of chloroform is flown into distillation column for purification. Upper product which is produced from distillation column is in the form of chloroform with the purification of 99%

CHAPTER IV
RESULT OF RESEARCH

From the economic analysis, can get value of BEP is 41.31%, this value still in the range are 40% - 60%. High of BEP value depend on price of product and raw materials. if price of product more high than raw material so the value of BEP will be decrease, but this is shown the plant profitably.

Value of ROI will be increase if value of BEP decrease. For POT value must bottom for 2 years (Plant with high risk) and in the chloroform plant, POT after tax is 0.95 years and high DCF is 44.50 % with loan in the bank is 25%. So plant of chloroform very profitably to building in Indonesia because can give high advantages and minimmize importing chloroform from overseas.

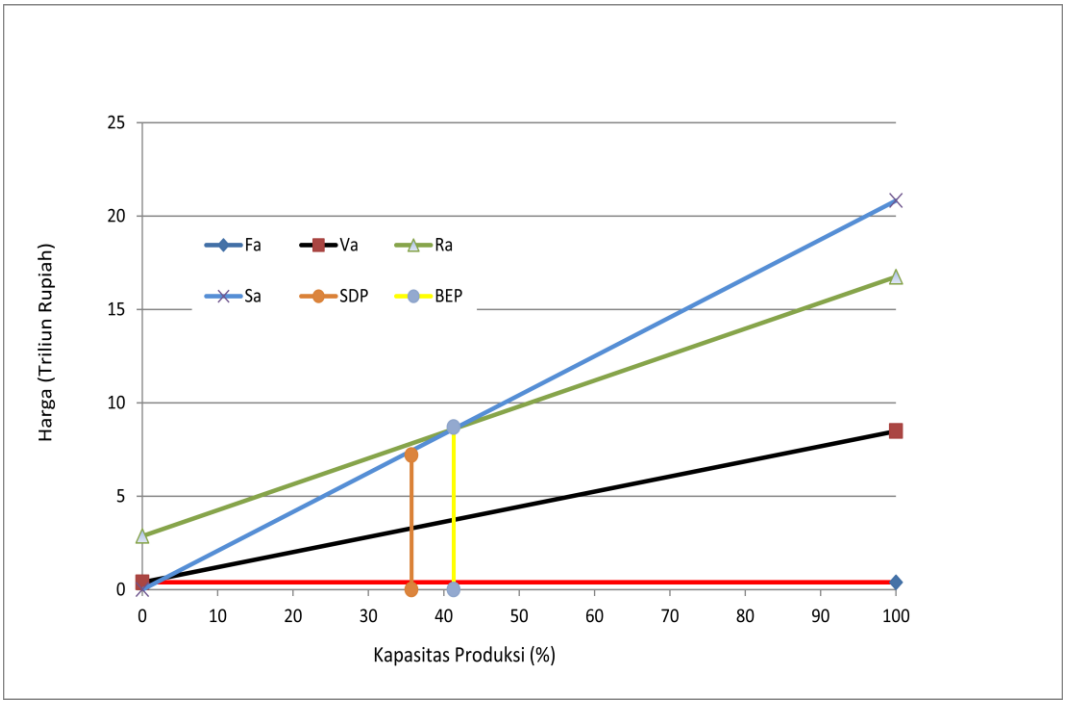


Figure 2.1 Graph of Feasibility Analysis

CHAPTER V

CONCLUSION

A. Conclusion

From the research of designning chloroform plant from acetone and chlorine with capacity 19,000 tonnes/annum, so can get the conclusion like this :

1. Precent Return On Invesment (ROI) before tax is 136.24 %
2. Precent Return On Invesment (ROI) after tax is 95.37%
3. Pay Out Time (POT) before tax is 0.68 years
4. Pay Out Time (POT) after tax is 0.95 years
5. Break-even Point (BEP) is 41.31 %
6. Shoutdown Point (SDP) is 35.72 %
7. Discounted Cash Flow (DCF) is 44.50%.

So this plant **Feasible** to build in the Cilegon,Banten.

BIBLIOGRAPHY

Amonette JE, PM Jeffers, O Qafoku, CK, Wietsma, and Truex. 2009. *Carbon Tetrachloride and Chloroform Attenuation Parameter Studies: Heterogeneous Hydrolytic Reactions*. PNNL-18735, Pacific Northwest National Laboratory, Richland, Washington.

Aries, R.S., and Newton, R.D. 1955. *Chemical Engineering Cost Estimation* , Mc Graw-Hill Book Co. Inc, New York.

Badan Pusat Statistik. 2014. *Statistik Perdagangan Luar Negeri Indonesia*.Jakarta.

Donald, E.G. 1989. *Chemical Engineering Economics.* Van Nostrond. New York.

Hani Handoko, T. 1990. *Manajemen Personalia dan Sumber Daya Manusia*. Penerbit Liberty, Jogjakarta.

Ketta, Mc. J.J. and Cunningham, W.A. 1992. *Encyclopedia of Chemical Processing and Design*. Vol. 40, Marcel Decker, Inc., New York

Keyes, F., and Clark, R.S., 1959, *Industrial Chemistry : 4 th edition*. John Wiley and Sons, Inc, New York.

Kirk, R.E., and Othmer, V.R. 1998. *Encyclopedia of Chemical Technology* : 4th ed. John Wiley & Sons Inc., New York

Levenspiel, O.. 1972. *Chemical Reaction Engineering* : 2nd ed. John Wiley & Sons, Inc., New York.

Perry, R.H. and Green, D.W. 1999. *Perry's Chemical Engineer's Handbook*, 7th ed. McGraw-Hill Book Company, New York

Peter, M.S. and Timmerhaus, K.D. 1980. *Plant design and Economic for Chemical Engineers*, 3rd edition, Mc Graw-Hill Book Company, Tokyo.

Pudjaatmaka, A.H., Setiono, L. 1984. *Buku Teks Analisis Anorganik Makro dan Semimikro*. PT Kalman Media Pustaka, Jakarta.

Severn, W.H., Degler, H.E., and Miles, J.C. 1954. *Steam, Air and Gas Power* : 5th ed. John Wiley and Sons inc., New York.

Smith, J.M. and Van Ness, H.C. 1996. *Introduction to Chemical Engineering Thermodynamics*, Prentice Hall, Englewood Cliffs., New Jersey.

Yaws, C.L., 1999. *Thermodynamic and Physical Properties Data*. Mc Graw Hill Book Co., Singapore.